Tag retention and mortality in inland reservoir channel catfish

Research Thesis

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By

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Abstract

Channel catfish (*Ictalurus punctatus*) is a popular sport fish that is native to Ohio and routinely stocked in reservoirs by the Ohio Department of Natural Resources-Division of Wildlife (ODNR-DOW). Toward helping the ODNR-DOW evaluate its stocking program, we experimentally tested the use of an internal, coded-wire tag (CWT) as a method for marking juvenile channel catfish that are released from the hatchery such that they can be differentiated from wild-produced channel catfish. The retention rate of CWTs and their effect on individual growth and mortality remain largely unexplored for channel catfish. Both attributes were quantified and compared between the two age-classes (i.e., age-0 fingerlings and age-1 yearlings) of channel catfish at various time points (i.e., after 1 week, 2 weeks, 1 month, and monthly thereafter) of our six-month experiment. For both age-classes, tag retention rates were high (90-100%), with no observed reduction in growth or increase in mortality. Our findings suggest that CWTs are a reliable, effective means of marking channel catfish, and hence, we recommend their use by ODNR-DOW to differentiate hatchery-reared individuals from wild-produced ones.

Introduction

Tagging is a commonly used tool in fisheries science and ecology that can help shed insight into population demographics and dynamics (e.g., growth, survival, movement, population size). Both natural (e.g., genetics, otolith microchemistry) and artificial tags can be used to differentiate individuals or groups of fish (Willis et al, 2009). Artificial tagging of fish prior to stocking is often used to help management agencies understand contributions that their stocking programs are making to the fishery, as the tags allow them to decipher natural fish from stocked fish (Daniels and Watanabe, 2010). This information can then be used to justify stocking numbers or change stocking practices (e.g., stock more or less fish; change age at stocking).

Artificial tags can be implanted internally and/or externally, and can simultaneously identify groups of individuals (e.g., fish tagged in a unique location; fish of a different size or age) or unique individuals within a group. When choosing a tag to use, one should assess its ease of use, costs, and potential biases. For this study, we used internal, coded wire tags (CWTs), which offer many advantages over other tags. An internal location was preferred over an external one because external tags can induce bias by increasing an individual's conspicuousness, which may change species interactions (e.g., increase vulnerability to predators; Ross and McCormick, 1981). Their small size (1.5 mm x 0.25 mm) and ability to attach to cartilage, connective tissues, and muscle has made CWTs one of the most effective, non-invasive internal tags (Bergman et al. 1992). For example, groups of individuals (e.g., size or age-classes; individuals captured in different locations) can be easily differentiated by inserting the CWTs in different locations of the body (e.g., cheek, caudal fin, pelvis; e.g., Tipping and Heinricher 1993).

Owing to their versatility, CWTs have been used with numerous freshwater species, including largemouth bass *Micropterus salmoides* (Williamson 1983; Crumpton 1985), red drum *Sciaenops ocellatus*, and striped bass *Morone saxatilis*, (Gibbard and Colura 1980), and tiger muskellunge *Esox masquinongy* X *E. Lucius* (Tipping and Heinricher 1993). While early studies using CWTs in fish demonstrated the potential for high tag loss and mortality, the negative effects from CWTs have diminished with improved technology and tagging methodology (Klar and Parker 1986; Heidinger and Cook 1988).

Herein, we sought to evaluate the effectiveness of CWTs for marking channel catfish (*Ictalurus punctatus*). This need exists because the only previous CWT efficacy research that has been conducted with this species focused on tag retention in adults (Heidinger and Cook 1988). These authors found tag loss to be less than 10%. However, as to whether these same results hold for younger ages of fish (e.g., age-0 and age-1 juveniles) remains unknown. This information gap is critical because the Ohio Department of Natural Resources-Division of Wildlife (ODNR-DOW) has expressed interest in using this methodology to differentiate hatchery-reared fingerlings (age-0) and yearlings (age-1) from wild-produced individuals such that the contributions that its stocking program has been making to the adult population and fishery harvest can be assessed.

Toward helping the ODNR-DOW determine whether CWTs could benefit their assessment efforts, we designed a controlled experiment that compared tag retention and tag-induced mortality between age-0 fingerlings and age-1 yearlings, as well as the effect of tagging on somatic growth. Following recommendations from the literature and expert scientists located at Northwest Marine Technologies and the US Fish and Wildlife Service (C. Becher, personal communication), we tagged age-0 fingerlings in the cheek and age-1 yearlings in the muscle located under the dorsal fin. The impact of these tagging locations has yet to be assessed in channel catfish, as Heidinger and Cook's (1988) marked their adult channel catfish in the nape and neck. Given findings from this previous study, as well as CWT research that has been conducted with other species (Ebel, 1974; Sharp et al, 2000), we hypothesized that tag retention would be similar to, if not better than what Heidinger and Cook (1988) found (i.e., $< 10\%$), with no expected negative effects on mortality or growth.

Methods

Study System

Channel catfish (*Ictalurus punctatus*) is a popular sport and food fish that is native to Ohio. Its relative importance to fisheries managers and hatchery production is driven by its popularity with Ohio anglers. Channel catfish are the third most desired species in Ohio reservoirs and are popular across its native range within the United States (Michaletz and Dillard 1999). In Ohio, approximately 10% of anglers prefer fishing for channel catfish to other species (ODNR-DOW 2013).

Channel catfish have been stocked by the ODNR-DOW in > 150 reservoirs statewide, predominantly with age-1 yearlings. Age-0 fingerlings supplement yearlings in stocked reservoirs only when a surplus of fingerlings exists in hatcheries. An overall assessment of the ODNR-DOW stocking program has yet to be conducted. Thus, as to whether age-0 fingerlings or age-1 yearlings recruit better to the fishery in Ohio reservoirs remains unknown. This uncertainty is important because the ODNR-DOW would prefer to only rear fingerlings, if their post-stocking survival and recruitment to the fishery was high, given the added expense of rearing yearlings in the hatchery for an extra year.

Fish Rearing and Tagging

The 200 juveniles used in this study were age-0 fingerlings (~5 mos of age) and age-1 yearlings (~ 17 mos of age) that were spawned and initially reared at the St. Mary’s State Fish Hatchery (St. Mary’s, OH). The fish were kept for the duration of this study in The Ohio State University-Aquatic Ecology Laboratory (OSU-AEL) pool facility from mid-October 2016 through the end of March 2017.

Prior to fish being assigned a pool and treatment, fish were immediately measured for total length (TL; nearest 1 mm) and mass (nearest 1 g). Fingerlings' lengths ranged from 66 mm to 181 mm TL and mass from 1.2 g to 44 g., while yearlings' lengths ranged 130 mm to 297 mm TL and their mass ranged 22 g to 244 g (Table 1). Individuals from both age-classes were randomly assigned to either a tagged or control (untagged) treatment (n=50 for each treatment) before being assigned to a random pool. Magnetic CWTs were implanted into the fish assigned to the tagged treatment in both age-classes (n = 100) using a MKIV single-shot injector (Northwest Marine Technology Inc., Anacortes, WA). Fingerlings were tagged in the check, just below the eye, whereas yearlings were tagged in the muscle below the dorsal fin. Immediately after tagging, every individual was checked for retention of the tag using a handheld wand detector (Northwest Marine Technology Inc.). If a scanned individual did not register as being tagged, the individual was tagged again, until a tag was registered. Finally, each fish was placed into the pool associated with its respective treatment.

We put 10 fish in each of twenty 2000 L pools. The pools are located within a 0.5 hectare outdoor facility, and thus experienced natural temperatures and processes (e.g. precipitation, light-dark cycle, noise). Each pool had continuous flow-through of dechlorinated city water and was aerated with air stones. However, during our experiment, a city water pipe burst that was associated with the water treatment plant that flows into the OSU-AEL pool facility. Consequently, excess chlorine (and possibly other chemicals) was added to the water at the Columbus city water treatment facility to kill foreign materials that enter its system. Therefore, high levels of chlorine overwhelmed the dechlorinating system (C. Becher, unpublished data) and we saw a spike in mortality immediately after this event. Once chlorine levels returned to non-lethal levels, the rate of mortality began to level out for both tagged and control fish of both ages (Figure 1). Prior to this event at approximately 80 days, no mortality was observed in any treatment.

Post-Tagging Monitoring

Fish behavior and mortality were monitored daily during pool inspections in accordance with IACUC protocol #2016A00000029. Signs of disease, injury, and irregular behavior (such as erratic swimming or lack of movement) were noted, to evaluate all influences of tags on fish behavior. Fish that were found dead were removed from the pools, checked for tags, and their TL was measured. Water quality variables, including temperature and dissolved oxygen, were measured daily in each pool using a YSI meter. In addition, pH and ammonium levels were monitored, and maintained below toxic levels to fish. Partial water changes (25%) were completed weekly. All debris and excess food were removed from the bottom of the pools during the water changes. Fish were fed once a week using sinking 3mm pellets (Classic Trout, Skretting USA) provided by the ODNR-DOW and followed their normal feeding regime; fingerlings were fed at 2.5% body weight and yearlings were fed at 5.0% body weight (C. Becher, personal communication).

To assess tag retention and growth, we removed fish from pools, placed them into holding buckets (~38 L), examined whether each individual's tag was still present, and measured its TL and mass 10 d, 20 d, 30 d, 60 d, 90 d and 120 d after the start of the experiment. Unfortunately, our CWT's did not allow us to track individual growth. Thus, to understand tagging effects on growth, we compared treatment means between the start and end of the experiment. We used a Z test to compare the proportion of individuals that died within each treatment by age-class.

Results

Mortality

Some mortality was observed in the experiment. After 120 d of monitoring, 28 fingerlings (11 tagged, 17 untagged) and 7 yearlings (4 tagged, 3 untagged) died. Although the percentage of untagged fingerlings that died (34%) was seemingly higher than that of the tagged fingerlings (22%) (Figure 1), these differences were not statistically significant ($Z = 1.34$, $df = 99$, $P = 0.18$). Similar results were found for the yearlings. The percentage of yearlings that died did not statistically differ between the tagged and untagged fish ($Z = -0.39$, $df = 99$, $P = 0.69$), with 8% and 6% of the tagged and non-tagged yearlings, respectively, dying.

Tag Retention

Tag retention was high in the study for both age-classes. At the conclusion of the 120-d period (and including all fish that died prior to day 120), tag retention was 100% in yearlings and > 95% in fingerlings (Figure 2). These differences in tag-retention were not statistically significant ($Z = 0.82$, $df = 199$, $P = 0.21$). All of the lost fingerling tags occurred in one pool for reasons that remain unclear, as no differences in water quality existed for any of the pools (C. Becher, unpublished data).

Growth

No effect of tagging on growth in TL was observed. Fish did not grow in length during the experiment, as mean TL was similar on day 0 and day 120 for all treatment groups. The average TL of the fingerlings did not differ on day 120 between the tagged or and untagged fingerlings ($t = 0.16$, df = 80.79, $P = 0.87$). Likewise, no difference in the average TL of yearlings was observed at the conclusion of the experiment ($t = 0.65$, df = 97.96, $P = 0.52$).

Tagged fingerlings were statistically different in mass compared to the control at Day 0. Therefore, we could not compare the two groups at day-120. However, the mass of tagged yearlings did not differ between Day 0 and Day 120 ($t = 0.56$, df = 90.93, p-value = 0.58). The mass of tagged fish was also not restricted as there was no decrease in mass of tagged fingerlings from day 0 to day 120 ($t = 1.62$, df = 85.46, p-value = 0.11). Again, similar results were seen in yearlings with no difference in mass between tagged and control fish from day 0 to day 120 ($t = 0.32$, df = 90.87, p-value = 0.75).

Discussion

Collectively, our results suggest that CWTs are suitable for marking age-0 and age-1 juvenile channel catfish. Our experiment showed no significant effects on mortality or somatic growth (in terms of both TL and mass), with tag retention being high (90% for fingerlings, 100% for yearlings).

Mortality

Some mortality (7% to 28%) was observed in our experiment. However, it appeared unrelated to tagging, and instead due to a chlorine spike associated with a burst pipe at a water treatment facility upstream of our experimental facility. Importantly, no mortality was observed for either fingerlings or yearlings prior to the burst pipe, which occurred ~ 80 days into the experiment. Further, temperature, pH, and ammonia levels remained below toxic levels for the duration of the experiment, further suggesting that chlorine spike was the cause of the observed mortality.

While tagging was not to blame, we did find that fingerling mortality was greater than yearling mortality. These results suggests to us that fingerlings may not be able to adjust as easily to changes in their environment as older individuals. Thus, while channel catfish are considered tolerant of pollution, being able to withstand varying habitats and water conditions (Tucker and Hargreaves, 2004), fingerlings may be more vulnerable to high or highly variable pollutant (e.g., chlorine) loads than yearlings.

Regardless of these differences, when considering the low mortality rates in tagged individuals for both age-classes, we do not see any evidence to suggest that fingerlings would be more adversely affected than yearlings by tagging. Furthermore, even if mortality was slightly higher in fingerlings than yearlings, this mortality could be offset by the ability of the ODNR-DOW to stock more fingerlings than yearlings. Doing so would be possible because fingerlings take up less space in the hatchery system and their small size and individual consumptive demands can allow fingerlings to be stocked at higher rates than their larger, yearling counterparts.

Tag Retention

Our tag retention findings are similar to other studies with CWTs. For example, Heidinger and Cook (1988) found tag loss to be less than 10% in adults, which is consistent with our findings with juveniles. Likewise, Ashton et al. (2014) found a similar result with juvenile burbot (*Lota lota*), which has a similar life-history as channel catfish. In fact, the only studies that found CWT retention to be low were those done decades ago, when CWT technology was in its infancy. Thus, our results suggest that CWT is a robust technology.

Growth

We found no negative effects of tagging on somatic growth in our experiment. Thus, while fish did not grow, which likely reflects the cold ambient environment, no loss of TL or mass was observed in any of the experimental pools. This result is encouraging, given that previous studies with CWTs and other artificial tags have shown that tagging can impair growth (Larsen, 2013; McFarlane and Beamish, 1990).

Conclusions

Tagging is a popular technique that has been used by many researchers and agency biologists to understand many attributes of fish populations, including growth, movement, survival, and population size. The successful use of tagging, however, requires that the rates of tag loss and mortality are known, as well as the effects of tagging on performance (e.g., growth). Our study has shown that CWTs are retained well in both age-0 and age-1 channel catfish, when tagged in the check or below the dorsal fin, respectively, and that growth and survival are not impaired by their use. Their use is especially encouraged, given the tagging process was minimally invasive and efficient, once the tagger became used to the process of handling fish and working the CWT injector.

Given the findings of our study, we recommend the use of CWTs in channel catfish applications involving both juveniles and adults. Our new-found ability to account for tag mortality and retention will benefit ongoing efforts by the ODNR-DOW to understand the contributions that stocked age-0 and age-1 channel catfish make to Ohio's reservoir fisheries. And, the ability to individually mark and identify hatchery-reared fish in a time- and cost-effective manner also should aid other agencies that are interested in asking questions about this, or other closely related species.

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	Fingerling		Yearling	
Size	Untagged	Tagged	Untagged	Tagged
TL (mm)	119.7 ± 18.4	131.5 ± 17.7	212.8 ± 32.0	216.9 ± 31.4
Mass (g)	16.3 ± 7.7	21.3 ± 8.4	82.2 ± 42.6	86.7 ± 43.7

Table 1. Total length (TL) and body mass in two age-classes of juvenile channel catfish tagged with coded wire tags. Data represent means ±1 standard deviation.

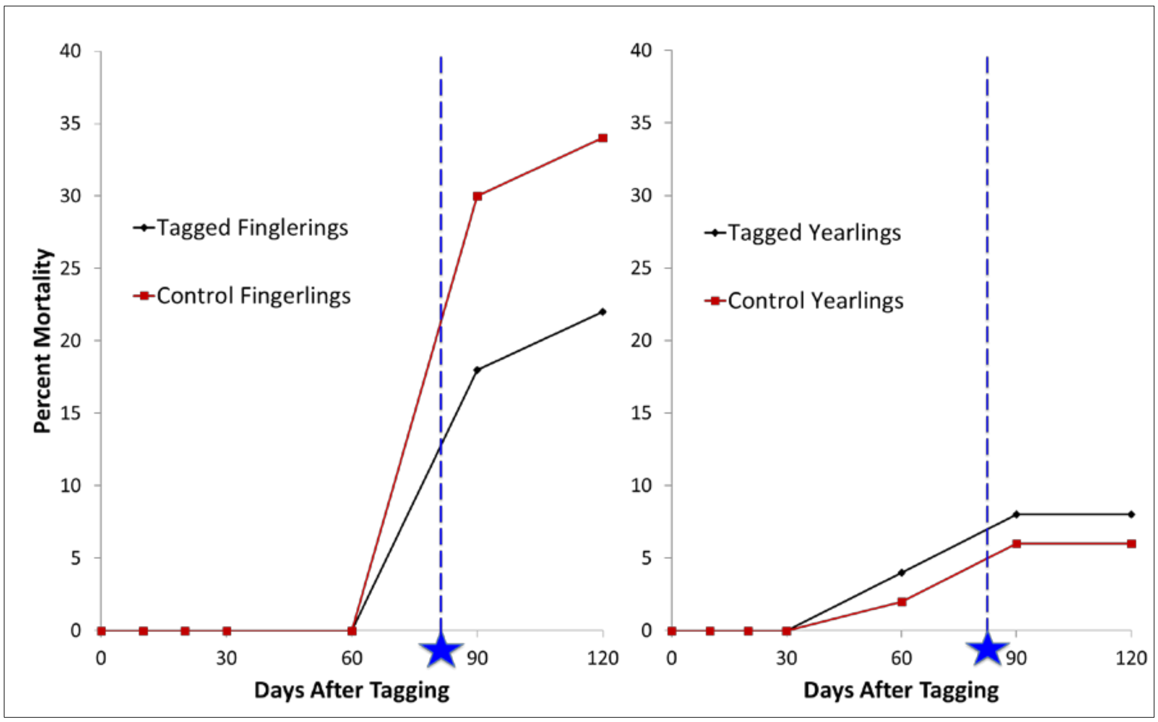

Figure 1. Mortality of tagged and control fingerling (left) and yearling (right) channel catfish over 120 d of captivity. The star and dotted line represent the day a water pipe attached to the water treatment plant from which we receive water burst. The added chlorine due to the burst overwhelmed our dechlorinating system.

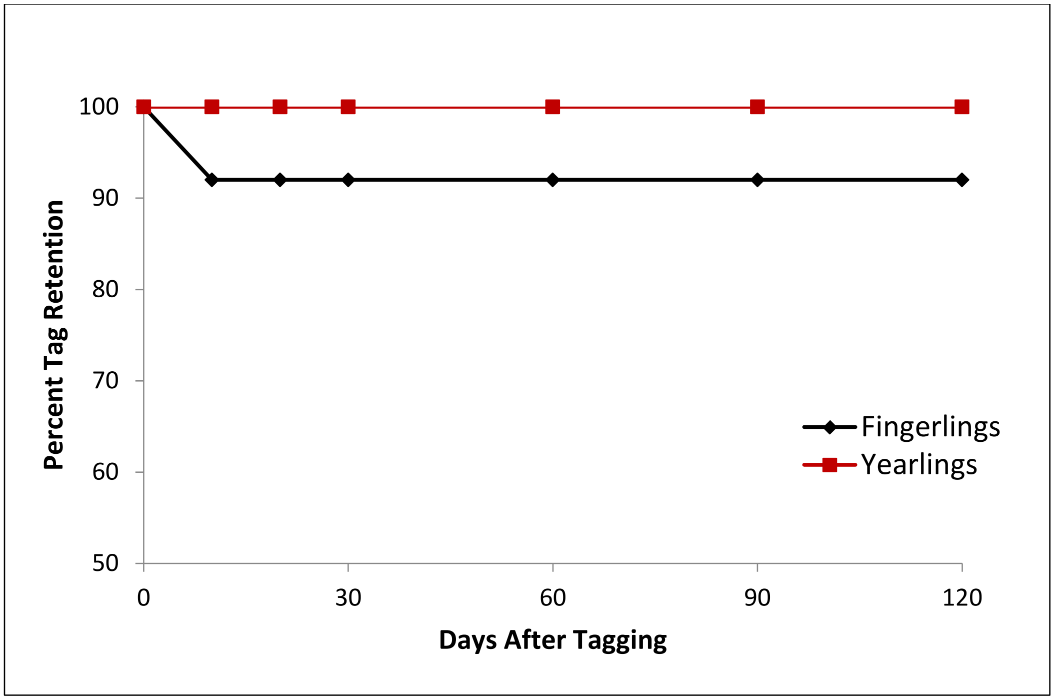

Figure 2. Tag retention for fingerling and yearling channel catfish during the 120-d experimental period.

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